MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2016/2017

ETN4106 – OPTOELECTRONICS AND OPTICAL COMMUNICATIONS

(All sections/Groups)

2 JUNE 2017
9:00 a.m. – 11:00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only.
2. Answer **ALL** questions. The distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1 (25 marks)

(a) Light transmission along an optical fiber can be described in terms of its mode of propagation.

(i) Compare TWO (2) differences between single mode fibers and multimode fibers. [4 marks]

(ii) Based on your answer in Q1 (a)(i), which type of fiber suffers from modal dispersion? Justify your answer. [3 marks]

(b) A step index single mode fiber has an acceptance angle in air of 12.25° and a relative refractive index difference of 1%.

(i) Calculate the numerical aperture for the fiber. Your answers should be up to two decimal points. [2 marks]

(ii) Determine the core refractive index. Your answers should be up to two decimal points. [2 marks]

(iii) Estimate the speed of light travelling in the core of the fiber. [2 marks]

(iv) Calculate the core diameter of the fiber if the wavelength of the light travelling in the core is 1550 nm and the cutoff normalized frequency, V_c is 2.405. [3 marks]

(c) The optical power launched into a 10 km length of fiber is 10 mW and the optical power measured at the fiber output is 2 mW.

(i) Assuming there are no connectors or splices in the fiber link, calculate the signal attenuation per kilometer (in dB/km) for the fiber. [3 mark]

(ii) Using the same fiber in Q1 (c)(i), if the fiber length is increased to 20 km, what is the total signal attenuation (in dB) in the fiber link? [2 marks]

(iii) Briefly describe TWO (2) loss mechanisms that contribute to attenuation in an optical fiber. [4 marks]

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Question 2 (25 marks)

(a) Based on quantum theory, the two processes by which light can be emitted from an atom is spontaneous emission and stimulated emission.

(i) Using energy state diagrams showing the initial and final state, describe stimulated emission process. [5 marks]

(ii) Name the emission process which provides the basic mechanism for the generation of light in a light emitting diode. [1 marks]

(b) For laser action to occur, it is necessary to contain photons within the laser medium and maintain the conditions for coherence. Describe the basic laser structure which allows this to be achieved. [4 marks]

(c) Photodetector is one of the components in an optical communication system which can affect the overall system performance. Describe TWO (2) requirements of photodetectors used in an optical communication system. [4 marks]

(d) A photodiode has a quantum efficiency of 70% at a wavelength of 900 nm. Calculate:

(i) The responsivity of the photodiode. [2 marks]

(ii) The photocurrent when the detector is illuminated with an optical power of 5 μW. [2 marks]

(iii) The rms quantum noise current with a post detection bandwidth of 30 MHz. [3 marks]

(iv) The signal-to-noise ratio (SNR) in dB, when the photocurrent is the signal. [4 marks]

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Question 3 (25 marks)

(a) Semiconductor laser amplifiers and fiber amplifiers are two categories of optical amplifiers.

(i) Optical amplifiers provide better performance over regenerative repeaters. Give TWO (2) reasons to support this statement. [4 marks]

(ii) Compare TWO (2) differences between a semiconductor laser amplifier and a fiber amplifier. [4 marks]

(iii) Describe TWO (2) ways to attain population inversion in an Erbium doped fiber amplifier (EDFA). [4 marks]

(b) An optical amplifier produces an output power of 25 dBm for an input power of 5 dBm at 1550 nm. Calculate:

(i) The amplifier gain. [3 marks]

(ii) The minimum pump power required when it is pumped at 980 nm. [2 marks]

(c) Two types of digitally modulated signals used in optical communication systems are non-return-to-zero (NRZ) and return-to-zero (RZ). Describe NRZ and RZ signals with suitable examples. [4 marks]

(d) An incoming light signal is transmitted in the form of the bit sequence '10110' and is modulated using a modulator. Assuming the signal is a sinusoidal carrier of very high frequency, illustrate the modulated signals when implementing frequency shift keying and phase shift keying. [4 marks]

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Question 4 (25 marks)

(a) The Asia Submarine Cable Express is an underwater optical fiber cable system which connects Japan, Malaysia, Singapore and Philippines. The length of the link is 7200 km. The data rate of the link is 40 Gbps.

(i) Suggest a suitable fiber type for this link. Justify your answer. [3 marks]

(ii) Is 1550 nm a suitable operating wavelength for this link? Give TWO [2] reasons to support your answer. [4 marks]

(iii) Propose a suitable optical source for this link. Justify your answer. [3 marks]

(iv) Suggest a suitable optical amplifier for this link. Justify your answer. [3 marks]

(b) An optical fiber link with the length of 20 km has system parameters as shown in Table Q4.

Table Q4

Maximum power of source	0 dBm
Minimum receiver power	-26 dBm
Fiber attenuation	0.25 dB/km
Number of connectors (connector loss is 0.2 dB per connector)	6
Splice loss	0.05 dB/km

(i) Based on Table Q4, calculate the total attenuation in the link due to fiber, splice and connector loss. [4 marks]

(ii) Calculate the power margin of the system. [4 marks]

(iii) Based on the power margin calculated in Q4(b)(ii), can the length of the optical link be extended? If yes, what is the maximum length possible, assuming that no optical amplifiers are used? [4 marks]

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Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^{8} m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

End of Paper